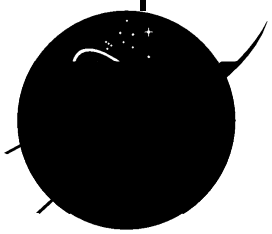
540-047

## MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

# Interface Control Document (ICD) Between the Earth Observing System (EOS) Data and Information System (EOSDIS) Backbone Network (EBnet) and Tropical Rainfall Measuring Mission (TRMM) Science Data and Information System (TSDIS)

**February 1997**



National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

# Interface Control Document (ICD) Between the Earth Observing System (EOS) Data and Information System (EOSDIS) Backbone Network (EBnet) and Tropical Rainfall Measuring Mission (TRMM) Science Data and Information System (TSDIS)

**February 1997**

Prepared Under Contract NAS5-31500
Task Assignment 46 505

**Prepared by:**

Chris Garman, Project System Engineer — Date
EOSDIS Backbone Network Project

**Project Management Approval:**

Steven A. Smith, Project Manager — Date
EOSDIS Backbone Network Project

**Division CCB Approval:**

Thomas E. Butler, Chairman — Date
Nascom CCB, Code 540

**Office CCB Approval:**

Dale Harris, Chairman — Date
ESDIS CCB, Code 505

**Approved by:**

Erich Stocker, Project Manager — Date
TSDIS Project, Code 902.3

**Goddard Space Flight Center**
Greenbelt, Maryland

# Preface

This document is under the configuration management of the National Aeronautics and Space Administration (NASA) Communications (Nascom) Division Configuration Control Board (CCB).

Proposed changes to this document shall be submitted to the Nascom CCB, along with supportive material justifying the change. Changes to this document shall be made by document change notice (DCN) or by complete revision.

Questions concerning this document and proposed changes shall be addressed to:

EBnet Program Manager
Code 540
Goddard Space Flight Center
Greenbelt, Maryland 20771

# Abstract

This Interface Control Document (ICD) describes interface agreements between the Tropical Rainfall Measuring Mission (TRMM) Science Data and Information System (TSDIS) and Earth Observing System (EOS) Data and Information System (EOSDIS) Backbone Network (EBnet).

***Keywords:*** *EBnet, ICD, Interface Control Document, TRMM, Tropical Rainfall Measuring Mission, TSDIS*

# Change Information Page

| List of Effective Pages | |
|---|---|
| **Page Number** | **Issue** |
| Title | Original |
| iii through viii | Original |
| 1-1 and 1-2 | Original |
| 2-1 and 2-2 | Original |
| 3-1 through 3-6 | Original |
| 4-1 through 4-6 | Original |
| 5-1 | Original |
| AB-1 through AB-4 | Original |

| Document History | | | |
|---|---|---|---|
| **Document Number** | **Status/Issue** | **Publication Date** | **CCR Number** |
| 540-047 | Original | March 1996 | |

# DCN Control Sheet

| DCN Number | Date/Time Group (Teletype Only) | Month/ Year | Section(s) Affected | Initials |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

# Contents

## Section 5. Facilities and Maintenance Demarcation



## Figures



## Tables



## Abbreviations and Acronyms

# Section 1. Introduction

## 1.1 Authority and Responsibility

The Mission Operations and Data Systems Directorate (MO&DSD) has the authority to implement Earth Observing System (EOS) Data and Information System (EOSDIS) Backbone Network (EBnet). This authority was granted to the MO&DSD by the EOS project, under the Office of Mission to Planet Earth (Code Y). The EBnet project is under the National Aeronautics and Space Administration (NASA) Communications (Nascom) Division of the MO&DSD.

Code 540 will provide an operational communications network to support high-speed network communications between EBnet and non-EBnet hosts. The primary responsibility for this project has been assigned to the Nascom Division, Code 540. The system requirements are documented by the references in Section 2.1. These have been approved by the EBnet Project Manager, and are controlled by the Nascom Configuration Control Board (CCB).

## 1.2 Purpose

The purpose of this document is to provide a detailed definition of the interface(s) between the EBnet and the Tropical Rainfall Measuring Mission (TRMM) Science Data and Information System (TSDIS).

## 1.3 Scope

This Interface Control Document (ICD) defines and controls the functions, communications protocol(s), frame formats, and electrical characteristics of the interfaces between EBnet-provided equipment, software, and communications paths and other entities that directly interface with the network. Interfaces provided by Nascom are included in the scope of this document. Interfaces between EBnet users and other systems not provided by Nascom are not within the scope of this document.

## 1.4 Time Frame

This ICD shall be in effect from the date of the last approval signature.

## 1.5 Goals and Objectives

The goals of EBnet are to:

a. Implement an operational, integrated, transparent communications system that serves the data communications needs of projects supported by NASA Goddard Space Flight Center (GSFC), and users outside the MO&DSD.

b. Expand using industry standard system solutions while maintaining compatibility with the existing network and user interfaces.

c. Minimize costs for implementation, operation, and maintenance of the network.

d. Minimize life-cycle costs.

e. Maintain high availability by designing with redundancy, and without single points of failure in the Network Backbone.

f. Utilize state-of-the-art technology, utilizing equipment with the best price-performance available commercially.

g. Allow for growth, adaptability to changing requirements, infusion of new technology, and upgraded interfaces throughout the life-cycle.

h. Provide for reliable data transfer between host systems and users.

## 1.6 Standards Precedence

EBnet will be based on Government, commercial, and international standards. In case of conflict, the following precedence (in descending order) applies:

- This EBnet ICD
- Government standards
- Commercial and/or international standards

## 1.7 Document Organization

Section 2 contains parent, applicable, and reference documents related to this ICD.

Section 3 details a systems overview of the EBnet, TRMM, and the interrelationship.

Section 4 describes the EBnet system architecture and identifies the standards supported at each level of the International Organization for Standardization (ISO) model.

Section 5 describes the facilities agreements.

A list of abbreviations and acronyms is provided at the end of the document.

# Section 2. Related Documentation

## 2.1 Parent Documents

[1] *Earth Observing System Detailed Mission Requirements*, Interim Draft Release, July 1995

[2] *Earth Science Data Information System (ESDIS) Project Level 2 Requirements Volume 6, EOSDIS Backbone Network (EBnet) Requirements,* Goddard Space Flight Center (GSFC) 505-10-01-6, December 1995

[3] *Earth Observing System (EOS) Data and Information System (EOSDIS) Backbone Network (EBnet) Interface Requirements Document (IRD),* March 1996

[4] *ECS External Traffic Requirements,* 223-CD-001-001, May 1996

## 2.2 Applicable Documents

[5] *Electrical Characteristics of Balanced Voltage Digital Interface Circuits,* Electronic Industries Association (EIA) 422-A, December 1978

[6] *General-Purpose 37-Position and 9-Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange*, EIA 449, November 1977

[7] *Internet Protocol (IP): DARPA Internet Program Protocol Specification*, Request for Comment (RFC) 791, September 1981

[8] *The Point-to-Point Protocol (PPP)*, RFC 1661, July 1995

[9] *An Ethernet Address Resolution Protocol or Converting Network Protocol Addresses to 48-bit Ethernet Addresses for Transmission on Ethernet Hardware*, RFC 826, November 1982

[10] *Internet Control Message Protocol*, RFC 792, September 1981

[11] *Routing Information Protocol (RIP)*, RFC 1058

[12] *Open Shortest Path First (OSPF),* RFC 1247

[13] *Internet Group Multicast Protocol (IGMP),* RFC 1112

[14] *On the Assignment of Subnet Numbers*, RFC 1219

[15] *Simple Network Management Protocol (SNMP)*, RFC 1157

[16] (reserved)

[17] *A Reverse Address Resolution Protocol (RARP)*, RFC 903

[18] *Internet Protocol on Ethernet Networks*, RFC 894

[19] *Transmission of IP over FDDI*, RFC 1188

[20] *Structure of Management Information*, RFC 1155

[21] *Management Information Base - II*, RFC 1213

[22] *Transmission Control Protocol*, RFC 793

[23] *Telnet Protocol*, RFCs 854 & 855

[24] *File Transfer Protocol*, RFC 959

[25] International Organization for Standardization (ISO) 9314-1, *FDDI Physical Layer Protocol (PHY)*

[26] ISO 9314-2, *FDDI Media Access Control (MAC) Protocol*

[27] ISO 9314-3, *FDDI Physical Layer Medium Dependent (PMD)*

[28] ISO 8802-2, *Logical Link Control (LLC)*

[29] ISO 8802-3, *Carrier-Sense Multiple-Access with Collision Detection (CSMA/CD) Media Access Control (MAC) - Ethernet version 2*

[30] Institute of Electrical and Electronic Engineers (IEEE) 802.3 *10Base-T (twisted pair)*

[31] IEEE *10Base5 (thick ethernet)*

[32] International Telegraph and Telephone Consultative Committee (CCITT) *V.35*

## 2.3 Reference Documents

[33] *NASA Communications (Nascom) Access Protection Policy and Guidelines*, 541-107, Revision 2, GSFC, August 1995

[34] *NASA Communications System Acquisition and Management*, NASA Management Instruction (NMI) 2520.1D, National Aeronautics and Space Administration (NASA), November 18, 1991

[35] *TSDIS Hardware Architecture Document*, TSDIS-P400, Version 2, September 29, 1995

[36] *Nascom IONET Users Guide*, 541-225, Revision 1, March 1996

# Section 3. Systems Overview

## 3.1 EBnet General System Description

The EBnet provides wide-area communications circuits and facilities between and among various EOS Ground System (EGS) elements to support mission operations and to transport mission data between EOSDIS elements. The relationship of EBnet to other elements supporting EOS is shown in Figure 3-1. EBnet is responsible for transporting spacecraft command, control, and science data nationwide on a continuous basis, 24 hours a day, 7 days a week. The EBnet capability to transport these diverse types of data is implemented as two distinct subnetworks referred to as "real-time" and "science" networks. The real-time network transports mission-critical data related to the health and safety of on-orbit space systems and raw science telemetry as well as pre-launch testing and launch support. This highly redundant network provides an operational availability of 0.9998 with a Mean Time to Restore Service (MTTRS) of 1 minute. The science network transports data collected from spacecraft instruments and various levels of processed science data including expedited data sets, production data sets, and rate-buffered science data. The science network provides an operational availability of 0.98 with a MTTRS of 4 hours.

EBnet provides three options for accessing the Internet Protocol (IP)-based EBnet transport service: local area network (LAN) Ethernet, LAN Fiber Distributed Data Interface (FDDI), and wide area network (WAN) carrier service. Figure 3-2 shows an example of each of these types of interface/demarcation points to EBnet users. This ICD describes the EBnet/TSDIS interface which uses the WAN and/or LAN interface types.

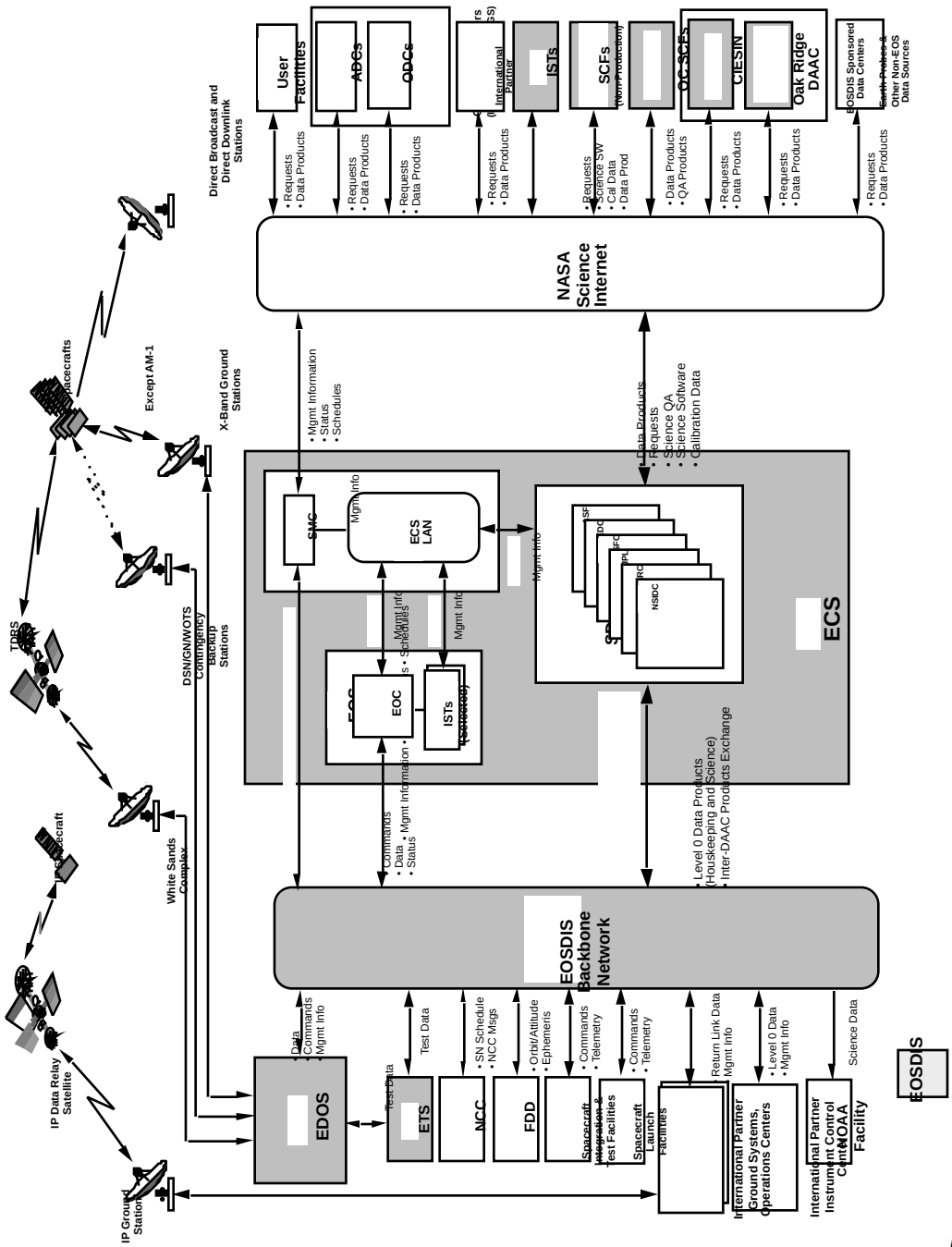



***Figure 3-1. EOS Ground System***

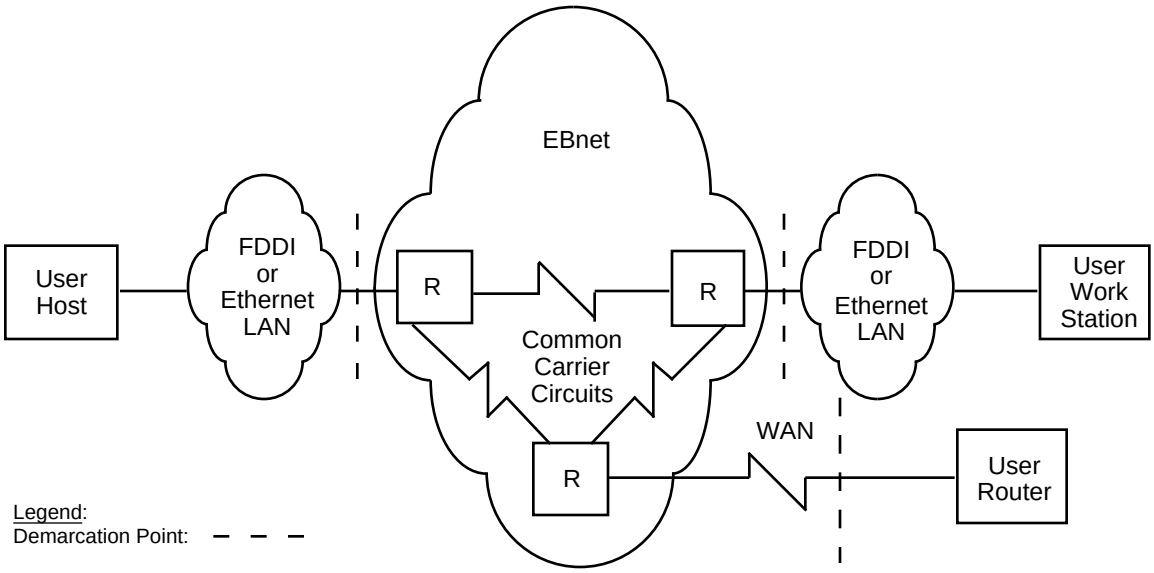



***Figure 3-2. EBnet Demarcations***

Sustaining engineering, preventive and remedial maintenance, and network monitoring services are provided for EBnet equipment, to ensure that EBnet keeps pace with technology and standards, and provides continuous service. The official point of contact for EBnet operational status is the Nascom Communications Manager (301-286-6141). Users who detect a network problem are urged to immediately report it to the COMMGR. The COMMGR may also provide users with limited information about maintenance and status actions. Refer to the Nascom IONET User Guide (541-225) for information regarding user connections, security guidelines, and maintenance information.

## 3.2 TSDIS Description

The TRMM project will receive Level 0 data from the Science Data Processing Facility (SDPF), process that data, and make it available to TSDIS Science Users. TRMM consists of two entities: the TSDIS and the TRMM Mission Operations Center (MOC), both located in Building 32 at GSFC. TSDIS is the data processing system and the MOC controls the satellite from the electronically secure Closed Segment of MO&DSD Operational/ Development Network (MODNET)/Nascom Operational Local Area Network (NOLAN). The TSDIS architecture is shown in Figure 3-3. The TSDIS workstations connect to an FDDI ring. A TSDIS router is the gateway to external connections through EBnet.

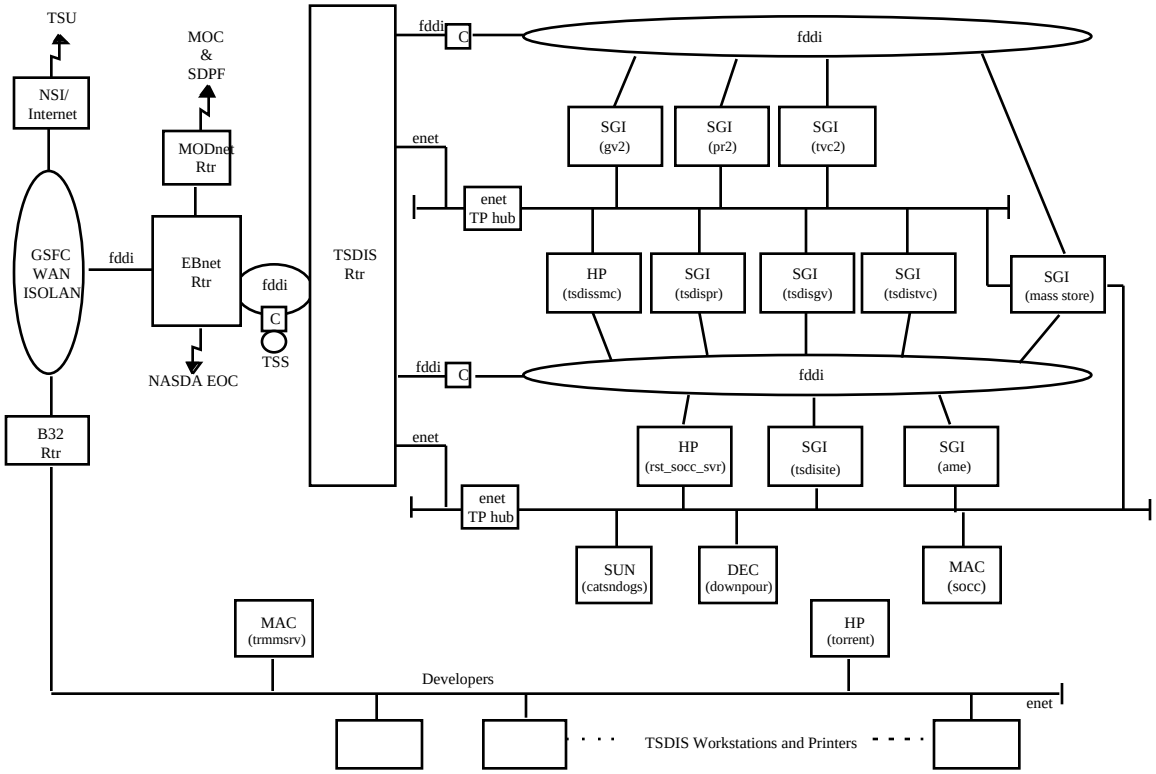



***Figure 3-3. TSDIS Architecture***

## 3.3 Relationship between TSDIS and EBnet

EBnet will support all TSDIS external interfaces as shown in Figure 4-1. TSDIS major data flows are to EOSDIS, specifically the TRMM Support System (TSS) located at GSFC. The TSDIS interface to the EBnet network management system will be status via Email of TSDIS-associated outages. These messages will be generated through the EBnet Network Operations Center trouble-ticketing system. Status information will also be available via a World Wide Web site maintained by EBnet.

# Section 4. Interface Detailed Design

## 4.1 Interface Design Overview

The TSDIS interfaces supported by EBnet, the GSFC Center Network Environment (CNE), and the NASA Science Internet (NSI) are shown in Figure 4-1. The TRMM interface data flow requirements, starting in the March-April 1996 time frame, will first be supported by the CNE (a network service which is supported 8 hours per day, 5 days per week). When the EBnet FDDI switches are installed and tested, a transition will occur to move the TSDIS over to the EBnet service, which is supported on a 24-hour, 7-day per week basis. Figure 4-2 shows the temporary configuration using the CNE network. Figure 4-3 shows the final EBnet-supported configuration. The transition will be accomplished by modifying the fiberoptic connections between wire closets in Building 32, and adding two additional FDDI-compliant fiberoptic cables between the EBnet switch and the local wire closet (W251C). The TSDIS router will be configured as a Dual-Attached Station (DAS).

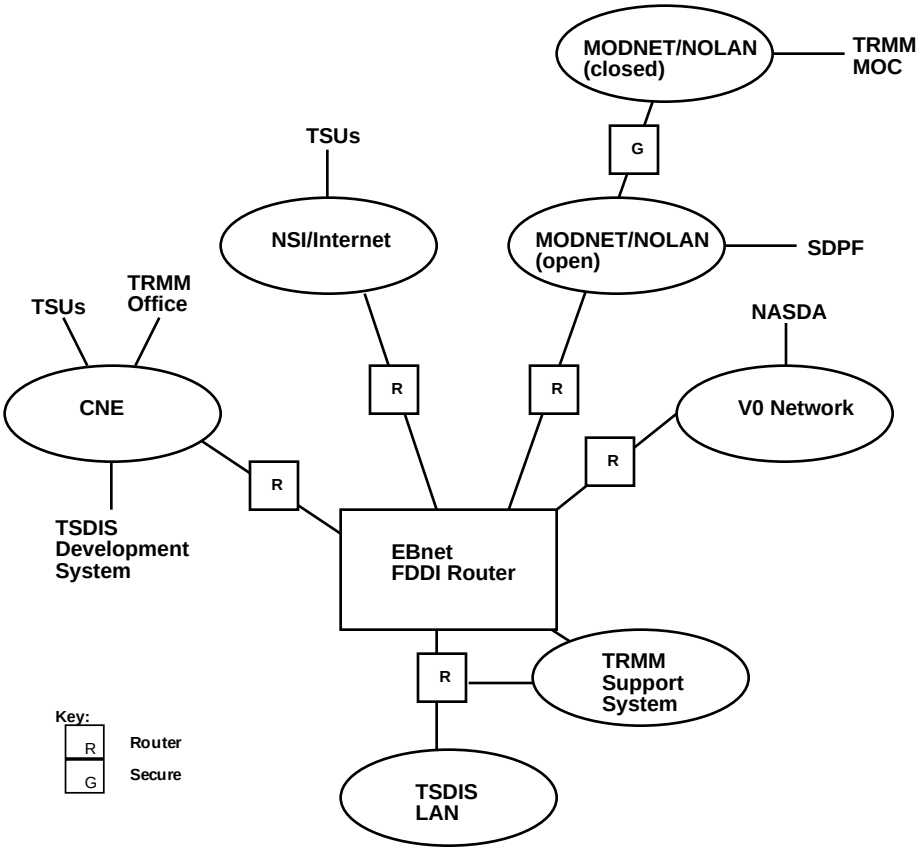



***Figure 4-1. TSDIS Interfaces***

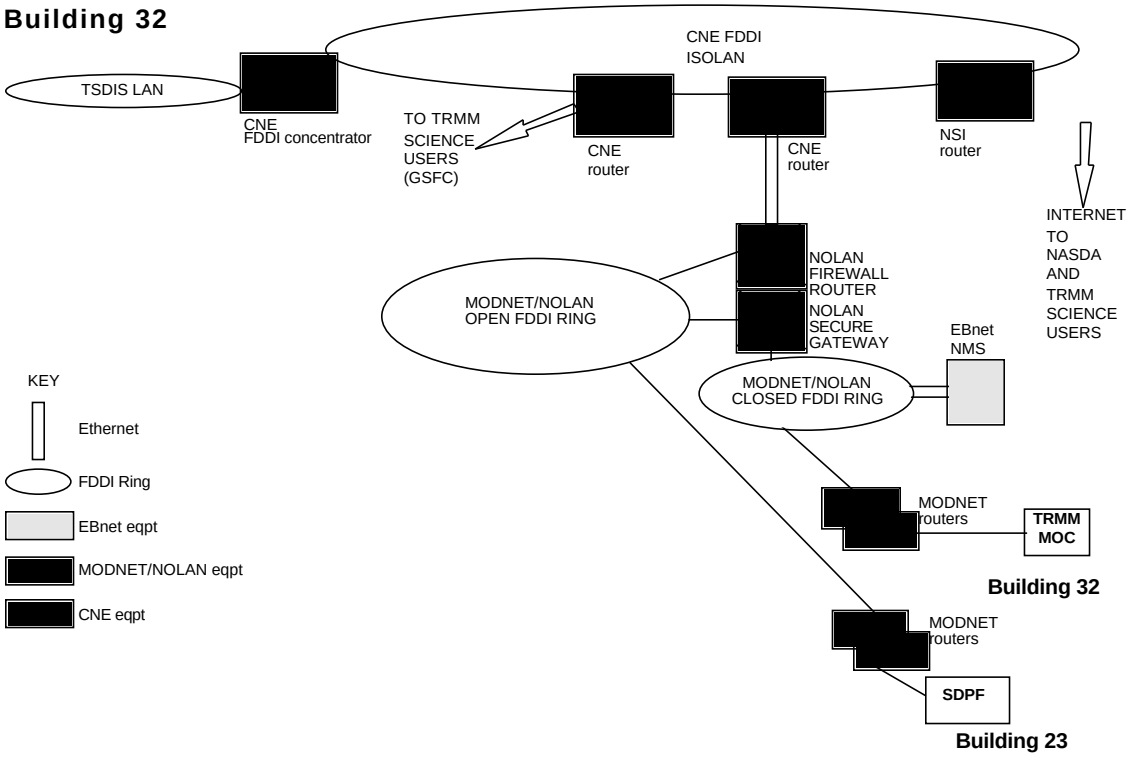



***Figure 4-2. EBnet Configuration Supporting TSDIS Interfaces (For IR-1 Testing via CNE)***

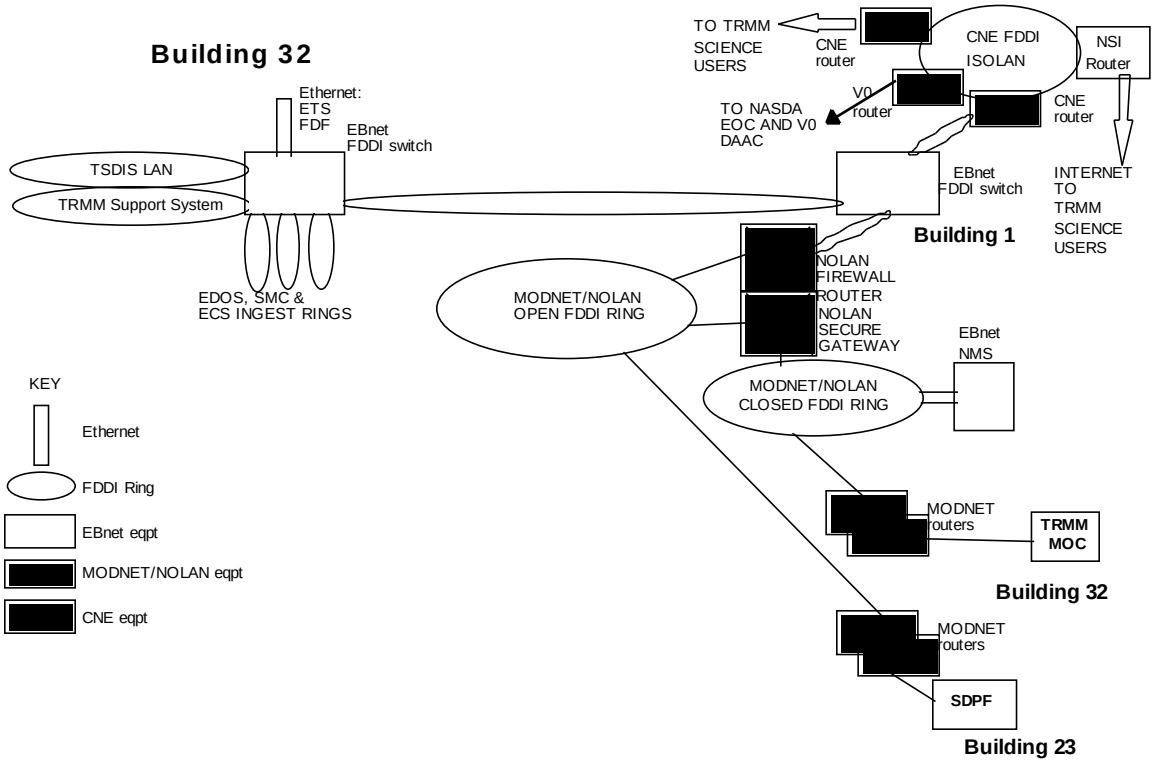



***Figure 4-3. EBnet Configuration Supporting TSDIS Interfaces (Release A and B via EBnet)***

## 4.2 Design Assumptions

TSDIS transfers no real-time data to external locations.

EBnet will provide network management using Simple Network Management Protocol (SNMP), including monitoring and control, for all EBnet-provided equipment (routers, concentrators, etc.). Read-only access must be provided for any user-provided routing equipment attached to EBnet. Reference the EBnet to Systems Monitoring and Coordination Center ICD (540-036) for further information.

EBnet routers will provide filters to support security on a subnet basis. No service or port-level filters will be supported.

## 4.3 Overview of System Interfaces

The following sections detail the standards that will be supported at each level of the ISO seven-layer model.

### 4.3.1 ISO Layer One Interface Control (Physical Layer)

EBnet will support the following physical layer connections from the TSDIS:

a. ISO 9314-1, FDDI Physical Layer Protocol (PHY)

b. ISO 9314-3, FDDI Physical Layer Medium Dependent (PMD)

### 4.3.2 ISO Layer Two Interface Control (Data Link Layer)

EBnet will support the following data link layer protocols from TSDIS:

a. ISO 9314-2, FDDI Media Access Control (MAC) Protocol

### 4.3.3 ISO Layer Three Interface Control (Network Layer)

EBnet will support the following network layer protocols from TSDIS:

a. RFC 791, Internet Protocol Version 4.0

b. RFC 826, Address Resolution Protocol (ARP)

c. RFC 903, Reverse Address Resolution Protocol (RARP)

d. RFC 1058, Routing Information Protocol (RIP)

e. RFC 1247, Open Shortest Path First (OSPF)

### 4.3.4 ISO Layer Four Interface Control (Transport Layer)

EBnet will support transparent communication at the transport layer.

### 4.3.5 ISO Layer Five Interface Control (Session Layer)

EBnet will support transparent communication at the session layer.

### 4.3.6 ISO Layer Six Interface Control (Presentation Layer)

EBnet will support transparent communication at the presentation layer.

### 4.3.7 ISO Layer Seven Interface Control (Application Layer)

EBnet will support transparent communication at the application layer.

### 4.3.8 Network/Station Management Protocols

EBnet shall support, at a minimum, the following management protocols:

a. SNMP

b. FDDI Station Management (SMT) 6.2 or higher

## 4.4 Routing and Addressing Guidelines

EBnet will be internetworked by routers which will be configured to support only the IP, and will provide isolation for separate networks. Bay Networks FDDI routers have been chosen to provide network access to users.

EBnet will utilize standard IP addressing conventions. EBnet will provide Class C subnet addresses to each connected user. The subnet address assigned to the TSDIS ethernet #1 (the bottom ethernet in figure 3-3) is 198.118.195.32 with a 224 subnet mask. The subnet address assigned to the TSDIS ethernet #2 (the top ethernet in figure 3-3) is 198.118.195.64 with a 224 subnet mask. The subnet address assigned to the TSDIS FDDI is 198.118.195.96 with a 224 subnet mask. The interface between the EBnet and TSDIS routers is implemented as a FDDI connection. The subnet address assigned to the interface between the TSDIS and EBnet routers is 198.118.195.128 witht a 224 subnet mask. This FDDI is also used as the TSS outer FDDI LAN. The Open Shortest Path First (OSPF) routing protocol will be used between EBnet and TSDIS routers.

## 4.5 Data Flow Requirements

The purpose of the interface between TSDIS and EBnet is to support connectivity between TSDIS and the various internal and external systems. All TRMM data flows supported by EBnet are solely science traffic.

***Table 4-1. TSDIS Data Flow Requirements***

| Network Interface | Initial Processing (MBytes/day) | Reprocessing (MBytes/day) | Total (MBytes/day) | Raw Transfer Total (Kbits/sec) Based on 16 hrs/day | EBnet Loaded Data Transfer Requirement (Kbits/sec) |
|---|---|---|---|---|---|
| TSS to TSDIS | 5 | 24,200 | 24,205 | 3,362 | 8,405 |
| TSDIS toTSS | 30,358 | 41,197 | 71,552 | 9,938 | 24,844 |
| NASDA EOC to TSDIS | 1 | 0 | 1 | .1 | 0 |
| TSDIS to NASDA EOC | 2 | 0 | 2 | .3 | 1 |
| SDPF to TSDIS | 2,065 | N/A | 2,065 | 286.8 | 717 |
| TSDIS to SDPF | minimal | N/A | 0 | 0 | 0 |
| TRMM MOC to TSDIS | 40 | N/A | 40 | 5.6 | 14 |
| TSDIS to TRMM MOC | <1 | N/A | <1 | .1 | 0 |
| TSUs to TSDIS | 2 | 2 | 3 | .4 | 1 |
| TSDIS to TSUs | 1,909 | 130 | 2,039 | 283.2 | 708 |

## 4.6 Recommended Equipment List

There will be no EBnet equipment located in TSDIS-controlled areas.

# Section 5. Facilities and Maintenance Demarcation

## 5.1 Equipment Location

EBnet will interface to the TSDIS router located in Building 32 at GSFC. EBnet equipment will be located in the EOSDIS Operations Center (EOC) Equipment Room, Building 32 Room C210-H.

## 5.2 Maintenance Demarcation

The demarcation point between EBnet maintenance and TSDIS maintenance is the connection at the TSDIS Router. Cabling will be provided and maintained by EBnet. TSDIS will provide 24-hour access to EBnet maintenance personnel for troubleshooting purposes.

# Abbreviations and Acronyms

| | |
|---|---|
| ADC | Affiliated Data Center |
| ARP | Address Resolution Protocol |
| ASF | Alaska SAR Facility |
| B | building |
| CCB | Configuration Control Board |
| CCITT | International Telegraph and Telephone Consultative Committee |
| CIESIN | Consortium for International Earth Science Information Network |
| CNE | Center Network Environment |
| CSMA/CD | Carrier-Sense Multiple-Access with Collision Detection |
| CSMS | Communication and System Management Segment |
| DAAC | Distributed Active Archive Center |
| DARPA | Defense Advanced Research Projects Agency |
| DAS | Dual-Attached Station |
| DCN | document change notice |
| DSN | Deep Space Network |
| EBnet | EOSDIS Backbone Network |
| ECS | EOSDIS Core System |
| EDC | EROS Data Center |
| EDOS | EOS Data and Operations System |
| EGS | EOS Ground System |
| EIA | Electronic Industries Association |
| enet | ethernet |
| EOC | EOSDIS Operations Center |
| EOS | Earth Observing System |
| EOSDIS | EOS Data and Information System |
| eqpt | equipment |
| EROS | Earth Resources Observation System |

| | |
|---|---|
| ESDIS | Earth Science Data and Information System |
| ETS | EOSDIS Test System |
| FDD | Flight Dynamics Division |
| FDDI | Fiber Distributed Data Interface |
| FDF | Flight Dynamics Facility |
| FOS | Flight Operations Segment |
| FOT | Flight Operations Team |
| FY | fiscal year |
| G | secure gateway |
| GCDIS | Global Change Data & Information System |
| GN | Ground Network |
| GSFC | Goddard Space Flight Center |
| GV | ground validation data |
| ICD | Interface Control Document |
| IEEE | Institute of Electrical and Electronic Engineers |
| IGMP | Internet Group Multicast Protocol |
| info | information |
| IONET | IP Operational Network |
| IP | Internet Protocol |
| IR | interim release |
| IRD | Interface Requirements Document |
| ISO | International Organization for Standardization |
| ISOLAN | isolated local area network |
| IST | Instrument Support Terminal |
| ITE | Integration and Test Environment |
| JPL | Jet Propulsion Laboratory |
| Kbps | kilobits per second |
| LAN | local area network |
| LaRC | Langley Research Center |

| | |
|---|---|
| LIS | Lightening Imaging Sensor |
| LLC | Logical Link Control |
| MAC | Media Access Control |
| Mbyte | megabyte |
| mgmt | management |
| MO&DSD | Mission Operations and Data Systems Directorate |
| MOC | Mission Operations Center |
| MODNET | MO&DSD Operational/Development Network |
| MSFC | Marshall Space Flight Center |
| msgs | messages |
| MTTRS | Mean Time to Restore Service |
| mux | multiplexer |
| NASA | National Aeronautics and Space Administration |
| Nascom | NASA Communications |
| NASDA | National Space Development Agency |
| NCC | Network Control Center |
| NMI | NASA Management Instruction |
| NMS | network management subsystem |
| NOAA | National Oceanic and Atmospheric Administration |
| NOLAN | Nascom Operational Local Area Network |
| NSI | NASA Science Internet |
| NSIDC | National Snow and Ice Data Center |
| ODC | Other Data Center |
| Ops | Operations |
| OSPF | Open Shortest Path First |
| PGS | Product Generation System |
| PHY | Physical Layer Protocol |
| PMD | Physical Layer Medium Dependent |
| PPP | Point-to-Point Protocol |

| | |
|---|---|
| PR | Precipitation Radar |
| QA | Quality Assurance |
| QC | Quality Control |
| R | router |
| RARP | Reverse Address Resolution Protocol |
| RFC | Request for Comment |
| RIP | Routing Information Protocol |
| RST | Remote Science Terminal Interface |
| SAR | Synthetic Aperture Radar |
| SCF | Science Computing Facility |
| SDPF | Science Data Processing Facility |
| SDPS | Science Data Processing Segment |
| SMC | Systems Monitoring and Coordination Center |
| SMT | Station Management |
| SN | Space Network |
| SNMP | Simple Network Management Protocol |
| SOCC | Science Operations Control Center |
| SW | software |
| TDRS | Tracking and Data Relay Satellite |
| TKSC | Tsukuba Space Center |
| TRMM | Tropical Rainfall Measuring Mission |
| TSDIS | TRMM Science Data and Information System |
| TSS | TRMM Support System |
| TSU | TRMM Science User |
| USGS | United States Geological Survey |
| WAN | wide area network |
| WOTS | Wallops Orbital Tracking Station |

# Distribution List

| Organization | Name of Recipient | Copies |
|---|---|---|
| GSFC/303 | Calvo, R. | 1 |
| GSFC/505 | desJardins, R. | 1 |
| GSFC/505 | Folts, H. | 1 |
| GSFC/510 | Johns, A. | 1 |
| GSFC/540 | Butler, T. | 1 |
| GSFC/540 | Garman, C. | 1 |
| GSFC/540 | Turner, V. | 1 |
| GSFC/541 | Torain, B. | 2 |
| GSFC/542 | Hill, P. | 1 |
| GSFC/505 | ESDIS Project Library | 1 |
| GSFC/542.2 | Communications Management Section Library | 1 |
| | | 16 |
| AlliedSignal Technical Services Corp. (ATSC) | | |
| ATSC/Nascom | Nascom CM Library | 1 |
| | | 1 |
| Booz, Allen & Hamilton, Inc. (BA&H) | | |
| BA&H/NMOS | EBnet Library | 1 |
| | | 1 |
| Computer Sciences Corporation (CSC) | | |
| CSC/SEAS | CM Library | 1 |
| CSC/SEAS | Technical Information Center (TIC) | 1 |
| | | 5 |
| Loral Aerosys (Loral) | | |
| Loral/SEAS | Pettengill, A. | 1 |
| | | 2 |
| TRMM | Cosner, C. | 1 |
| TRMM | Pryor, H. | 1 |
| TRMM | Stocker, E. | 1 |
| | | 3 |